Determination of the Solar Parallax from Spectroscopic Observations of Venus

Observations of wave-lengths in the spectrum of *Venus* have been made at Mt. Wilson during the last two elongations for the purpose of checking Evershed's results.[1] A detailed account of the observations, with a discussion of them as related to Evershed's hypothesis of an "Earth-effect," will appear soon in the *Contributions of the Mount Wilson Observatory*. In reducing these observations for wave-lengths the relative velocity of *Venus* with respect to the Earth and Sun must necessarily be taken into account. This involves the value of the solar parallax and, as has been pointed out before, furnishes a method of determining that constant[2].

Spectroscopic observations for solar parallax promise to furnish determinations comparable to other methods in precision. Their value lies in the probably compensating character of the errors inherent in different methods. For a star near the ecliptic the Doppler displacements are about twice as great as those observed for *Venus*, but in the case of *Venus* the greater brightness of the object allows the use of higher dispersion. In either case long series of observations are possible, making for low probable errors. The number of stars available gives added weight to stellar observations, but the lack of knowledge of conditions that may affect the displacements of the spectral lines in individual stars introduces uncertainties.

In 1905 Küstner published the results of his spectrographic observations for solar parallax, in which he used *αBootis* and obtained the value of $\pi = 8''.829 \pm 0''.013$[3]. Probably the best spectroscopic determination is that obtained at the Royal Observatory, Cape of Good Hope[4], the detailed account of which is summarized by A. B. Turner in these PUBLICATIONS for October, 1912.

Our observations were made with the Snow telescope in connection with a Littrow grating spectrograph. The diameter of *Venus* varied from 1.3 to 3.3 mm. The slit was 0.05 mm. wide, its position in general being approximately normal to the terminator. The spectrograph as used gives a linear dispersion of 3A per mm. Altho the grating was very bright in the first order, exposures of about one hour were necessary. Exposures were made upon the iron-arc simultaneously with exposures upon *Venus* or the sky. The wave-lengths of thirty lines in these spectra were measured

[1] *The Observatory*, **42**, 51, 1919.
[2] *Publ. A. S. P.*, **19**, 196, 1907.
[3] *A. N.* 4048-4049, 1905.
[4] *Annals of the Cape Obs.* **10**, Part 3, 1909.

and reduced by identical methods and the observed differences between wave-lengths in the *Venus* and sky spectra were made the basis of the investigation.

Differences between the observed and computed velocities of *Venus* might be caused by a rotation of the planet, unless special precautions have been made to eliminate that effect; but the spectroscopic observations of Slipher[5] furnish very definite evidence of a long rotation period and it seems much more probable that such differences should be attributed to an erroneous solar parallax. Our spectrograms were not measured for inclinations of the lines, but the slight astigmatism of the grating was such that it is doubtful whether rotation of the planet would have been shown in this way, even if the guiding and seeing had been perfect. Altho rotation of the planet produces equal and opposite velocity displacements at the limb and terminator[6], the distribution of velocity over the disk is such that the integrated effect is not zero. A computation of the effect of rotation in producing displacements requires assumptions which are very uncertain, but if the rotation period of *Venus* is of the same order as its period of revolution the error introduced by neglecting the rotation can not affect the solar parallax by a thousandth of a second.

Plates taken at high and low altitudes on several nights showed that the measured wave-lengths were systematically shorter for the lower altitude in both morning and evening observations. After eliminating from all the observations the effect of altitude, which is well represented by the empirical equation $\Delta\lambda . 10^{-3} = 1.5 - 1.0 \cot h$, there still remained slight systematic displacements to the violet which could be correlated with the relative position of Earth, *Venus*, and Sun. These are well represented by any one of the following equations:

$$\Delta\lambda . 10^{-3} = +1.5 - 3.0\ (1 - \cos \mathrm{VSE})$$
$$\Delta\lambda . 10^{-3} = +0.8 - 3.5 \cos i$$
$$\Delta\lambda\ 10^{-3} = -2.8 + 0.28R$$

where VSE is the angle *Venus*—Sun—Earth, i is the phase angle of *Venus*, and R the semi-diameter in seconds of arc. These two types of displacement are no doubt similar to those experienced by other observers and must be eliminated before the results can be used for parallax determinations. Since they have the same sign in morning and evening observations, and the effects of an erroneous value of the parallax appear with opposite signs, it is possible to

[5] *Lowell Obs. Bull.*, **1**, 9, 1903. Bull. No. 3.
[6] *The Observatory*, **42**, 308, 1919.

eliminate the systematic errors by combining the means of the two series, provided the conditions of observations are the same in both.

In our observations these conditions were not exactly fulfilled and the observed difference of 0.0012A between the means of the two series was reduced to 0.0006A when the observations were corrected by applying the empirical equations referred to above. The mean wave-length of the lines measured was $\lambda 4500$, so that this 0.0006A is equivalent to a difference between the observed and computed velocity of 0.04 km. per sec. for the two series. In all, 56 *Venus* plates were measured, the probable error for a single plate being ± 0.20 km. The calculated correction to the adopted solar parallax of $8''.80$ is $+0''.013 \pm 0''.017$.

The corrections deduced by Hinks from the photographic observations of *Eros* range from $+0''.014$ to $-0''.035$ for different observers, his adopted value being $+0''.007 \pm 0''.0027$[7]. In the spectroscopic determination at the Cape of Good Hope the corrections obtained from individual stars varied from $+0''.035$ to $-0''.036$, the adopted parallax being $8''.800 \pm 0''.006$. The parallax deduced from our *Venus* observations is a by-product from spectrograms taken for other purposes; since it falls well within the range shown by other determinations, it is probable that a very reliable parallax could be obtained from a program of observations planned for the purpose.

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THE PLANETARY DISKS OF NOVA AQUILAE NO. 3

Slitless spectrograms and visual observations of *Nova Aquilae* No. 3 with the 100-inch reflector show very distinct markings within the $H\alpha$ and N_1N_2 disks. On September 9, visual observations at the primary focus, with seeing 6 on a scale of 10, showed a bright bar crossing the nebular disk in p. 40°, approximately. The spectrograms made the same night show a short bright line crossing the center of the N_1N_2 disk, extending more to one side than the other. On September 10 the seeing averaged about 2, but at moments of better seeing the bar was easily observed.

On October 5, at the Cassegrain focus, with seeing 3, slitless spectrograms of 2, 6, and 10 minutes exposures were obtained with a focal plane spectrograph, the focus being intermediate between red and blue-green. A strong continuous spectrum appears, crossed by

[7] *M. N.*, **67**, 70, 1906.